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Color Standards for White Potato Granules

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WHITE POTATO GRANULES are dehydrated precooked white potatoes in granular form. Color is generally an index of over-all quality of potato granules, with darker colors associated with a scorched or otherwise improperly processed product. It was the aim of the present work to prepare permanent color standards which would be useful in procurement and for quality control during production. For this application the lightness attribute of color is of predominant importance. The color of potato granules is not sufficiently stable to make feasible the use of selected granule samples themselves as standards. Instead, formulations were developed which were based on glass beads comparable in size to the individual potato granules. The beads when mixed with dry powdered inorganic pigments provide satisfactory appearance as well as color matches for the granules. Three such formulations were made, representing colorwise the borderline of acceptability for military procurement, and typically good (light) and typically poor (dark) granules *(4)*.

THE GRANULES SELECTED FOR COLOR MATCHING

From a variety of sources about 40 samples of potato granules were collected, ranging in color from very good to very poor. Samples were grouped into 3 categories on the basis of color and classified as products of good, borderline and poor color. One sample from each category was selected as representative of the group and used for the development of the permanent color standards. The range of color between the selected good and poor sample was small; the color designation according to the ISCC-NBS method *(3)* for all 3 samples being either yellowish white or pale yellow. Spectral reflectance data (relative to magnesium oxide) are shown for the potato granules as the dotted curves in Figure 1. Chromaticity coordinates based on the 1931 CIE standard observer and Illuminant C, computed by the method of weighted ordinates from the reflectance values and standard colorimetric data *(2)* are listed in Table 1. The color difference, $\Delta E = 3.8$ NBS units, between borderline (B) and good (G) granules was essentially equal to that between borderline and poor granules (P), $\Delta E = 3.9$ NBS units. In terms of lightness or luminous reflectance, ΔR_c, the difference between B and G was 6.1%, and between B and P was 5.5%. The chromaticity coordinates and luminous reflectances of the granules were adopted for specification purposes *(4)*, and preparation was undertaken of standards which would match these specifications within small tolerances.

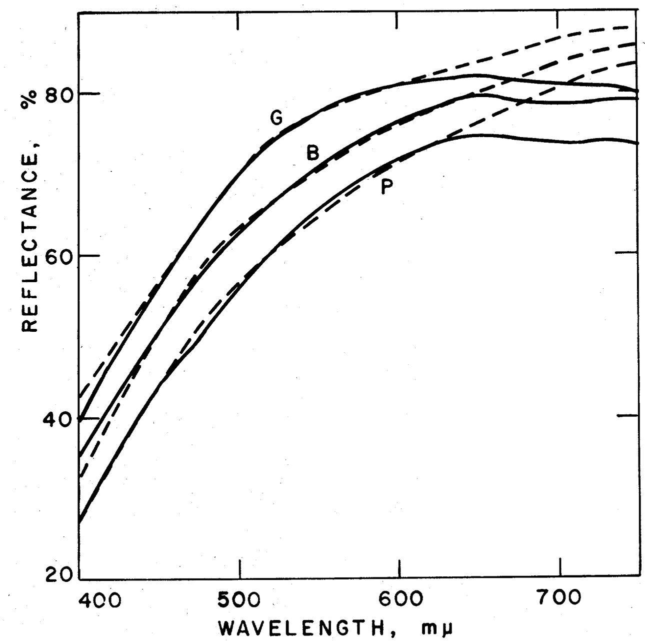

Figure 1. Reflectance spectra of good, borderline and poor potato granules (dotted lines), and matching permanent color standards (solid lines).

[a] Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

TABLE 1

Colorimetric data on white potato granules and permanent color standards; CIE data are based on 1931 standard observer and Illuminant C

	Potato granules			Color standards		
	Good	Borderline	Poor	Good	Borderline	Poor
Chromaticity coordinates x	0.3372	0.3427	0.3496	0.3377	0.3432	0.3503
y	0.3500	0.3530	0.3580	0.3518	0.3531	0.3603
Luminance reflectance, R_c, %	76.9	70.8	65.3	76.8	70.8	65.4
Dominant wavelength, Λ, mμ	574.6	576.0	576.8	574.2	576.1	576.3
Excitation purity, P, %	16.3	18.6	21.8	16.9	18.7	22.6
Munsell notation	5.5Y 8.9/1.9	3.5Y 8.6/2.3	2.5Y 8.3/2.8	5.5Y 8.9/2.0	3.5Y 8.6/2.3	3.0Y 8.3/2.9
Color difference, Δ E, between granules and standards, NBS units	......	......	......	0.9	0.2	1.0
Lightness difference, ΔR_c, between granules and standards, %	......	......	......	−0.1%	0.0%	+0.1%

To be lifelike, color standards must approximate the texture of the granules judged. Granules are simply individual cells of potato tissue, for the most part intact; the thin cellulosic cell wall encloses the original cell contents, obviously modified by gelatinization of the starch and disappearance of the starch granules during the cooking. Like the potato cells the potato granules are roughly isodiametric. Under the microscope they present an appearance resembling that of fragments of glass, somewhat irregular in shape, and with rounded and roughened surfaces. The distribution of sizes in a 200-gram sample of granules was determined by sieving, with the results shown in Table 2. The small amount of material retained on 40- and 60-mesh sieves consisted mostly of vascular fibers, peel fragments and clumps of granules. For the whole sample the maximum in the weight distribution versus size curve corresponded to a diameter of about 150 μ.

TABLE 2

Size distribution in a sample of potato granules

Sieve number		Weight per cent
Passed	Retained on	
40	60	0.8
60	80	16
80	100	19.5
100	120	49.5
120	140	0.5
140	170	5.5
170	270	7.5
270	325	0.8

MATERIALS FOR THE COLOR STANDARDS

The principal component of the standards was fine glass beads of the sort used in projection screens. In form the beads are essentially spherical and their light-diffusing characteristics are considerably different from those of potato granules of the same size; even when properly pigmented, mixtures based on 150 μ diameter beads were so grossly inadequate in texture as to be unacceptable as color standards. It was found, however, that spherical glass beads of nominal diameter 75 μ would make an acceptable base for the color standards, and as such comprised 80 to 90% of the weight. As a lightening agent a finely powdered white glass with reflection qualities approaching those of MgO was used, in proportions of 10 to 20%. Three colorants were used, in total amount of 0.4 to 0.6%. They were pigments employed in production of vitreous tiles and had the following characteristics:

Color designation *(3)*	Munsell notation	
Light yellow	2.5Y	8.5/6
Moderate yellow	5.0Y	8/7
Moderate orange yellow	7.5Y	7.5/6

The beads as received from the supplier were too heavily contaminated with dark material to be useful directly. Oversize beads and part of the dark contaminant were eliminated by sieve-classification, discarding all material retained on a 100-mesh screen. Happily the remaining dark contaminant was strongly paramagnetic and could be removed by passing a fine stream of the beads over an apex of the pole of a small horseshoe magnet. After being cleaned in this way the entire quantity of beads, amounting to about 18 lbs., was thoroughly mixed.

PREPARATION AND TESTING OF THE COLOR STANDARDS

Trial formulations were prepared in approximately 20-g. amounts. Chosen quantities of the colored pigments were tumbled with a somewhat larger weight of the white glass powder. This was done in a 1-ounce square glass jar containing several ¼ in. and ⅜ in. stainless steel balls, and revolved on the rollers of a miniature ball mill. This initial mixing occupied 1 to 3 hours. When microscopic examination showed that the colorant particles were well dispersed, the remainder of the glass powder was introduced and the tumbling was resumed. Finally, the glass beads were added and mixed with the powders in a similar manner; impact of the balls was not so severe as to damage the beads.

When mixing was complete the spectral reflectance of the sample was recorded over the range 400 to 750 mμ by means of a General Electric spectrophotometer[b] (Figure 1). The sample was contained in a metal cell, equipped with a thin glass window, and so designed that reproducible filling was achieved easily. The depth of the sample was about 1 cm. The comparison surface was MgO viewed through glass from the same piece used in the window of the sample cell. CIE data were derived from recorded reflectance curves with the aid of a General Electric semi-automatic tristimulus integrator and the method of 30 selected ordinates.

When a sufficiently close chromaticity and lightness match for the potato granules was achieved, larger batches were made in essentially the same manner. It was not possible to duplicate mixing conditions precisely, and minor adjustments in the proportions of colorants had to be made in all of the larger batches in order to obtain satisfactory color. In our experience the larger batches were slightly darker than was expected from the formula worked out in the small scale trials. Reflectance values for the final color standard mixtures were read from the spectrophotometer dial at 10 mμ intervals, and converted into CIE data by the weighted ordinate method. The closeness of the spectral match between the granules and color standards is evident from Figure 1.

PACKAGING AND MODE OF USE

As containers for the color standards and the potato granule samples to be graded, 2-ounce square, wide-mouth flint glass jars provided a workable compromise among optical quality, cost and other practical requirements *(1)*. The jars are cheap enough that, with small total outlay, a sufficient number can be selected with suitably flat faces, adequate uniformity of wall thickness and freedom from bubbles and other imperfections. The wide-mouth glass jars are easily filled and emptied and easily cleaned. Compared with cells fabricated from colorless plastic they are resistant to scratching, solvents and frictional electrification. Compared with fused glass cells of even quite ordinary optical quality, they are far less expensive. Compared with both plastic and glass cells, they offer the advantage of reliable, convenient closure through screw caps. Although glass jars with rectangular rather than square cross-section would be more economical of the color standard mixtures, no such jars of adequate optical quality could be obtained. A worthwhile economy in the color mixture was achieved by inserting a capped glass vial at the center of the 2-ounce square jars before filling.

Decalcomanias identifying the color standards were applied to inside surfaces of selected jars, the jars were filled, the necks wadded with cotton, and black plastic screw caps secured by means of cellulose acetate cement.

A technically adequate, simply built, inexpensive illuminated chamber was devised for making color comparisons between granule samples and the standards (Figure 2). In essence this is a plywood box 22 in. long, 15 in. wide and 19 in. high, open at the front except for a strip 7 in. wide extending downward from the top. The strip has the dual function of preventing light from the lamps from striking the observer's eyes and minimizing the effect of room lighting on the illumination of the samples. The chamber is illuminated by two 15-watt fluorescent "daylight" lamps mounted with white enameled reflectors on the ceiling. The lamps are spaced equidistant from each other and from the front and back of the box. The daylight lamps provide light approximating Illuminant C in quality, and at a level of about 200 foot-candles in the area where the color comparisons are made. The interior of the cabinet, and the sample holder, are finished in dull black.

[b] Mention of specific firms and companies does not imply endorsement of their products by the Department of Agriculture to the possible detriment of others not mentioned.

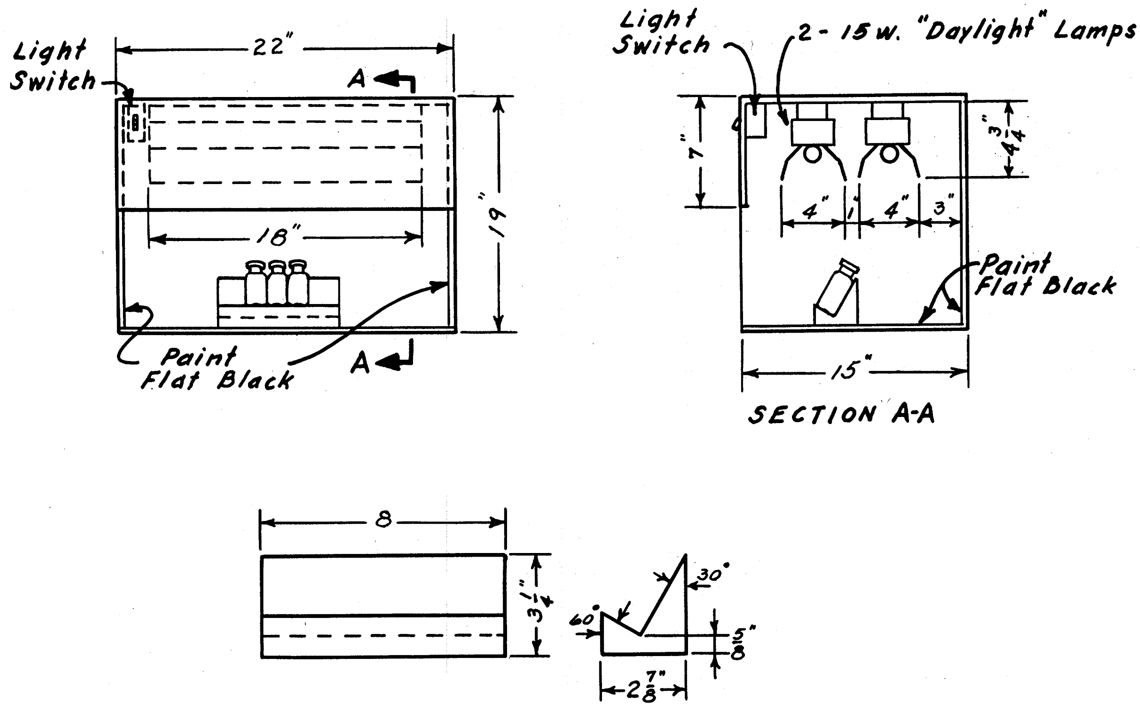

Figure 2. Cabinet and sample holder for color comparison of potato granule samples and standards.

Jars containing samples and standards are placed on a rack as illustrated in Figure 2. The axis of the jars is 30° from the vertical. A thin blackened metal sheet with rectangular apertures was put in front of the jars to mask out the edges, shoulders and caps. At the cost of cumbersomeness this produced an esthetic improvement but no advantage in color discrimination, and was discarded.

DISCUSSION

Twenty-five sets of the 3 color standards were prepared. Chromaticity and other data on the standards are listed in Table 1. The lightness difference between granules and standards is gratifyingly small, 0.1% or less. Color differences between granules and standards, computed by the Nickerson-Stultz formula (*2*, page 265), with f = 40, are also quite small.

It was noted that the granule samples on which color specifications were based became strikingly yellower during 2 years' storage at room temperature in the dark in glass containers, compared with the same samples kept at 40° F. Spectrophotometrically the refrigerated granules were essentially unchanged, and visually matched the permanent color standards very well.

SUMMARY

Color is generally an index of over-all quality of potato granules, with darker colors associated with scorched or otherwise improperly processed granules. A color specification based on the spectral reflectance of selected granule samples has been incorporated into the military specifications for white potato granules. Three stable color standards, representing the borderline of acceptability and typically good and typically poor granules, have been prepared. Twenty-five sets of these standards have been transferred to the Quartermaster Food and Container Institute for the Armed Forces for use by QM inspectors and for loan to commercial producers of granules. Inexpensive, technically adequate illuminators and containers have been devised for comparison of granule samples with the color standards.

LITERATURE CITED

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